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6. Finally in problems of thermodynamics, there would seem to be no valid objection to its use. In the characteristic equation for a pure gas, the product of the new reading and the gas constant give as before a measure of the kinetic energy of translation of the molecules. Similarly in Avogardo's law, we have an even more definite conception of the temperature function; and also in the Stefan-Boltzmann law of black body radiation.

ON THE IMMUNITY COLORATION OF SOME NUDIBRANCHS

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Certain large nudibranchs, notably species of *Chromodoris*, exhibit a combination of brilliancy of pigment pattern and boldness of habits sharply distinguishing them from related nudibranchs which appear to be efficiently protected by their concealing coloration and behavior. It has long been suspected that the strikingly colored chromodorids achieve an immunity from predatory enemies by virtue of some distasteful quality, according to the classical conception of 'warning coloration.' The experimental evidence for this belief, as presented by Herdman and by Crossland, has remained, however, very fragmentary and is indeed far from carrying conviction.

For several years I have been interested in the pigmentation of the large Bermudian *Chromodoris zebra* Heilprin, mainly because its blue integumentary pigment is available as an intracellular indicator of acidity. On the basis of field observations, continuous throughout the year, I was led to undertake a series of experiments intended to throw light upon the possible biological meaning of this animal's coloration. The outcome seems reasonably conclusive, and it leads to the rejection of the idea that a warning significance attaches to the pigmentation of *Chromodoris*. By inference, one is inclined to suspect that more complete study will reveal analogous conditions with reference to other brightly colored nudibranchs.

The pigment pattern of *C. zebra* is, in brief, an irregular streaking of yellow or orange upon a field of blue. The foot, the ventral surface of the mantle, and various less conspicuous parts are of a pure blue. The animals occur at various stations, ranging in depth from about 10 fathoms to the surface of the water. They are most abundant, though, in quite shallow water, except during a portion of the summer and immediately after severe storms at other seasons. Their coloration is always conspicuous, not only because of its brilliancy but also by reason of the freedom with which they expose themselves in bright sunlight upon bare open bottoms or (a favorite situation) on eel grass in tidal 'creeks.' The animals are positively phototropic. Their conspicuousness is entirely independent of their being viewed form above the water surface.

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Less than two per cent of the specimens collected are found to show evidence of mutilation. As these nudibranchs regenerate very slowly (Child, and my own observations), this evidence is significant.

Experiments in feeding entire, undamaged specimens of this nudibranch to other animals, both in natural surroundings and under favorable conditions in aquaria, have shown that to all the animals usually associated with *Chromodoris* its flesh is repugnant. This is true of fishes as well as invertebrates, including anemones, crustacea, various worms, and starfish. Some fishes which feed by night (squirrel fishes), and others which hunt their prey by sight (snappers), will make several attempts to bite a *Chromodoris* when it is first dropped into their aquarium tank, but thereafter will not approach it; after the nudibranch has sunk to the bottom and begun its normal creeping, it is never seriously molested.

The unpleasant quality is associated with the skin, since the internal organs are greedily devoured. The blue pigment is not the unpleasant substance, for the intensely blue rhinophores are eaten readily, while the blood, which I have elsewhere shown to contain the blue skin pigment (presumably as a respiratory chromogen of some sort), evokes positive food-taking responses from various fishes, crabs, and anemones. The yellow pigment is not the responsible agent, as it is absent from the edge of the mantle, a region which comparative tests indicate to be the most 'unpleasant' part of the animal's body.

Small pieces of the skin of *Chromodoris* will be snapped at several times by a fish (over twenty species have been tested), while an intact nudibranch will usually be merely approached, 'nosed,' and perhaps bitten once, if the fish swims up suddenly, before it is left alone. The explanation of this behavior is found in the fact that when the intact nudibranch is locally disturbed by being handled severely, bitten, cut, stung by nematocysts, or stimulated with induction shocks, it excretes from the irritated area, into the sea water, a bluish-white material which causes immediate negative reactions in fishes and in all classes of marine invertebrates which I have tested. Isolated portions of the *Chromodoris* skin, however, give the reaction with difficulty, if at all, and then only to a slight extent.

It is significant that the secretion comes mostly from the ventral surface of the mantle. When this nudibranch is disturbed, its first reaction is a general contraction, in which the mantle edge is extended and made prominent by internal fluid pressure; the edge of the mantle is invariably the region which is bitten at by fishes, and it is only the part which is damaged in the small number of mutilated specimens found in the field. There exists here, I believe, an interesting case of adaptive correlation.

As excreted, the repelling material contains globules of the blue skin pigment, which seems to be accidentally included in the discharged substance; but it is mainly a coagulated white substance holding oily globules. It is this substance which is the essential repellant.

There is still another phase of the matter, which is the most significant of all. A striking characteristic of these nudibranchs is the curiously penetrating, disagreeable odor which attends them even when they are undisturbed. To this is to be assigned responsibility, I believe, for the facts, (1) that cloth bags containing *Chromodoris* are avoided by fishes; (2) that blinded fishes avoid them; and (3) that animals never normally in contact with *Chromodoris*, such as the dogfish, remora, and the hawksbill turtle, will approach this nudibranch closely, then quickly retreat without touching it. The olfactory locus of these reactions seems probable, but it does not necessarily involve the idea of 'warning odor.'

In the present instance we have, in my opinion, positive proof for the validity of the theory of immunity coloration developed by Reighard. According to this view, startling colors are in many (if not in most) cases "conceived to have arisen through internal forces under immunity of the organism from the action of selection on its characters." The immunity of *Chromodoris zebra* is determined by the repugnatorial character of skin secretions under the control of its nervous system, and is further made effective by a repelling odor, which we have reason to believe stimulates the olfactory organs of fishes at least. Its success in maintaining itself as a plentiful inhabitant of the shoal waters of a 'coral' reef region is conditioned by this immunity and by the unpalatable nature of the jelly surrounding its egg strings; the slow rate of development of its eggs is counterbalanced by the fact that the animals reproduce throughout the year.

The coloration of *C. zebra* is a metabolic accident, at least in relation to its protection, for a single experience with a normally colored specimen is sufficient to cause snappers, turbots, and groupers to have nothing to do with subsequent individuals offered to them, even though these individuals are stained red or blue.

Conceivably, its color may at times serve to warn predatory foes, but the evidence herein adduced makes it clear that the pigmentation of *Chromodoris* plays no necessary rôle of this kind. We are consequently at liberty to infer that the conspicuous coloration did not develop, as the result of selection, according to the scheme proposed by the theory of warning coloration.

An illustrated account of this work will be submitted for publication later.

SOME EFFECTS OF THE CONTINUED ADMINISTRATION OF ALCOHOL TO THE DOMESTIC FOWL, WITH SPECIAL REFERENCE TO THE PROGENY

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1. In a recent number of these PROCEEDINGS there was presented[2] a summary statement of the results which had been obtained up to February 1, 1916, in a series of experiments designed to test the effect upon the progeny of the continued daily administration, by the inhalation method, of either ethyl alcohol, methyl alcohol, or ether to the parents, the domestic fowl being the form used in the work. The chief result was that the offspring of parents which had inhaled the vapor of one or another of the substances mentioned, for one hour each day over an average period of 210 days each, were measurably *superior* to the offspring of untreated parents in respect of the following characters or attributes: prenatal mortality, postnatal mortality at all ages, weight at hatching, adult weight, rate of growth, and percentage of abnormalities or defects of development. The offspring of untreated parents were superior to those of treated parents only in respect of their number; the untreated parents produced a larger total number.

It is the purpose of the present paper to report in brief and condensed, but numerical, form the results which have been obtained since the data at which the former report ended. The data included are those obtained in the breeding and rearing season of 1916. The length of the period over which the parents had been given daily treatments was of course longer by one year than in the 1915 breeding season. Thus the total germ dosage index[3] for the 1916 matings ranged from 458 to 1138, with a mean value of 562.9 days, for the parental generation, and from 0 to 266, with a mean of 40.6, for the grandparental generation.